Electronic Poster: Physics track: Adaptive radiotherapy for inter-fraction motion management

EP-1805

Design and testing of the Rotating Whole-Body Linac-MRI Hybrid System

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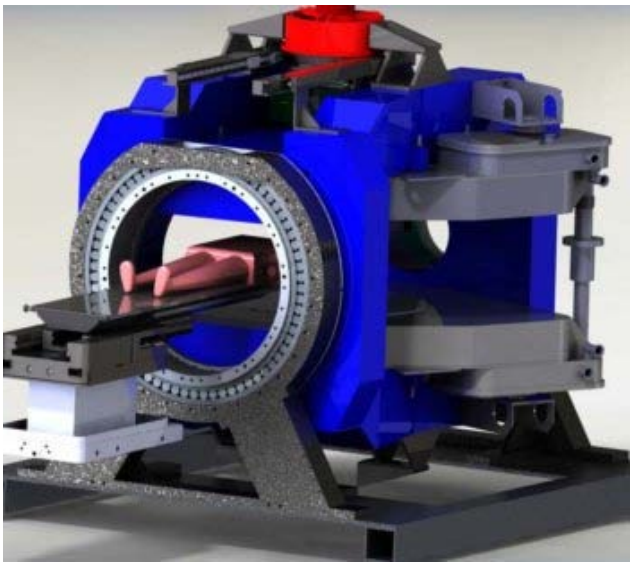
Purpose or Objective: The first whole-body clinical linac-MRI hybrid (linac-MR) began installation in November 2013 at our clinic. System components were transported through the maze of an existing clinical radiotherapy vault and reassembled within the vault without removal of any part of the vault. The world-first images from a linac-MR on a human volunteer were obtained in July 2014. Specific imaging and dosimetric evaluation are reported.

Material and Methods:



The linac-MR (Figure) consists of an isocentrically mounted 6 MV linac that rotates in-unison with a bi-planar 0.5 T MRI in transverse plane. The Bo field and the central axis of the 6 MV beam are parallel to each other. Feasibility of operation of concurrent MR imaging and linac-irradiation was confirmed in 2008 within a head prototype, while the current functional whole-body rotating linac-MR system is built on the engineering and physics developed and tested on the head prototype. The magnetic fringe field are optimized with the parallel configuration to results in insignificant entrance-dose increase and to avoid large increases in dose at tissue/air interfaces and any increase at beam exit due to electron return effect.

Results:

Table: Specifications of current rotating linac-MR system

Feature	Characteristic
Linac	6 MV
MLC	120 Leaves (Standard, Micro)
MR	0.5T (Good Image Resolution) (Negligible Geometric Distortion)
Maximum Pre-treatment Field of View	40 cm x 75 cm
Patient Space	Exterior Opening: 110 cm Diameter Interior Space: 60 cm x 110 cm (Rotating) Result: Suitable for Treating All Tumors (Including Peripheral Tumors — Breast)
Patient Table Movement Inside the Aurora RT	Vertically ± 25 cm Laterally ± 25 cm
Linac-MR Configuration	Aligned — Rotate Together
MR Position	Rotates 360 degrees
Beam-Orientation	Parallel to Magnetic field (minimal dosimetric perturbation)
Bunker and Maze Size	Standard for Linacs (Installation Through Maze)
MR Cryogens and Venting	None Required
Beam Modulation	IMRT, VMAT
Soft-tissue Imaging	Four Images/sec During Tx
Treatment Planning	Real-time Adaptive
Servicing	Ramp up/down in Minutes To Allow Servicing of Linac

Currently, the whole body system is mechanically well balanced and rotates at 1 rpm, and provides because of its open-magnet design imaging and irradiation to tumours in all locations, including peripheral areas and breast. The system provides radiation output resulting in minimal dose perturbations in entrance dose, at internal tissue-air/lung interfaces as designed and no exit dose-increases. 3D magnetic field mapping demonstrates minimal perturbation in magnetic field homogeneity with gantry rotation which is easily and effectively shimmed by gradient coils. The Larmor Frequency varies with gantry angle due to the Bo interaction with room shielding and to the directional changes of the Earth's magnetic relative, and closely follows predictions calculated previously. Angle dependent 3D magnetic field maps and Larmor Frequency are used to automatically and optimally create image acquisition parameters for any gantry angle. Metrics obtained at different rotating angles show that the image quality is comparable to those of clinical MRI systems, and thus satisfy the requirements for real-time MR-guided radiotherapy.

Conclusion: The system highlights (Table) are:
6 MV linac; High-quality MR images during irradiation; parallel configuration to avoid strong angle-dependent shimming, and increased dose at beam exit and tissue-air/lung interfaces; imaging and irradiation of all tumours including peripheral areas and breast; installation through the maze of existing vaults; cryogen-free superconducting magnet; magnet turns on or off in minutes for safe servicing of magnetic components.

EP-1806

A novel predictive approach to quantify parotids warping using SIS epidemic model

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